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together with a plan of the whole, as he believes it appeared in its original splendor and perfection; that posterity may not be deprived of informations, which are of so great benefit and importance to all lovers of architecture. It is also said, that the engineer [carpenter], who invented the scaffolding, has made an exact model of it for him; which he intends to publish as a part of the work before-mentioned.

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**XVII.** *An Account of a new medicinal Well, lately discovered near Moffat, in Annandale, in the County of Dumfries. By Mr. John Walker, of Borgue-House, near Kirkudbright, in Scotland.*

Read Feb. 10, & Mar. 3, 1757. **T**HIS mineral spring was found out by one Mr. Williamson, a few years ago, when he was overseeing a mine, which was at that time carrying on in its neighbourhood. It is situate about four miles distant from Moffat, in the bottom of a deep scar, which is on the west side of a large mountain called Hartfell, from which it has acquired the name of Hartfell-spaw. This scar is a part of the mountain, thro' which a small stream of water has worn its way to a considerable depth; by which it has laid open, and exposed to view, the strata of the earth on each side: and in the bottom of this scar, and near to the brink of this small brook, the mineral water springs up. When

When I saw it, it consisted of two springs, which were very well ordered by Mr. Williamson, so as to run from two wooden spouts, immediately at their rise out of the earth; which indeed must be of very great advantage to all mineral waters: and I am persuaded there are many, whose medical qualities are greatly impaired by falling into reservoirs, and continuing in them for some time after they spring from the earth. The one of these springs was situate about ten or twelve yards further up the brook than the other; and they were then distinguished by the names of the upper and lower spring: but I have been since informed, that their situation is now altered. Each of these springs did at that time run nearly the same quantity of water, which, as I thought, was above an English quart in a minute, and that during a season of very dry weather.

As there are many instances of mineral waters springing out of the earth very near each other, which at the same time are impregnated with very different principles; it therefore seemed not at all improbable, that as these waters did appear to run, for some part of their course, in different channels, they might in some respects be different from each other. And this suspicion I found not to be altogether groundless with regard to these springs, as will be shewn afterwards. For which reason it may be observed, that the following trials were all made upon the water of the upper fountain, except where the other is particularly mentioned; and also that they were made within 24 hours after the water was taken from the spring, being carried to Moffat in bottles carefully sealed.

According

According to what may be inferred from the following experiments, it may be premised, that this water appears to contain in it a large proportion of iron, but in two different forms; and an aluminous salt, which is conjoined with a terrestrial principle.

As the contents of several mineral waters have been the cause of many different opinions, and of great disputes among physicians and chymists; as the inquiry I made into the principles of these waters, which I am now considering, was not performed with that nicety and exactness I could have wished; and as I am persuaded, that to dogmatize in any branch of philosophy can never tend to its advancement; I shall not therefore pretend to determine with certainty in any part of this subject, where the contrary opinion can be admitted with the least degree of probability. These trials are indeed but few and imperfect, and are no way sufficient to form an exact account of this mineral water; yet I believe they may afford some conclusions, which may be serviceable in compiling a more compleat history of it. They render it pretty evident, that the above-mentioned principles are contained in these waters: and tho' I will not pretend absolutely to exclude all others, yet I must say, that, by what inquiry I made, I could not observe them to be in the least impregnated with any other kind of mineral substance.

After a good deal of observation upon the water of this Spaw; and after many fruitless attempts, which I have at different times made upon several other waters of the chalybeat kind in Scotland, in quest of the volatile spirit, which has been commonly attributed to them; I must own, that I have been  
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induced to think, that there is no such thing exists in these waters at all. What has been generally called the spirit of steel waters, seems to me to be very unintelligible; altho' the existence of it in these waters has been asserted by all the writers on this subject, which I have yet had occasion to see. The spirit of a mixed body is commonly taken to be a subtile, penetrating, light, and volatile substance, more susceptible of motion than any other of its parts, and most easily separable from them by avolation. But that any chalybeate water contains such a substance, I think has never been made evident, unless where the water has been found to be impregnated with some other mineral principles. Some steel waters, I believe, contain a large proportion of air, whose elasticity may occasion it to break forth with an explosive force; some others there are, which contain a volatile and sulphureous halitus; and to one or other of these two causes, or to some other mineral principle, I think most of the phænomena may be referred, which have been attributed to a ferrugineous or vitriolic volatile spirit.

As the first thing observable in a mineral water is its outward form, we must therefore take notice, that the water of this Spaw equals the clearest spring-water in transparency; and is likewise as free of any colour or odour: yet its taste is very strong, and may be discerned to be compounded of a sweet, subacid, and astringent taste. Its sweetness and acidity appear sensibly to arise from alum; and its high styptic and astringent taste does as evidently proceed from that mineral salt, joined with some earthy or ferrugineous parts. I must likewise observe, that when

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I first compared the taste of these two springs, I could plainly discern, that the water of the lower spring was more acid, and less astringent, than that of the upper one; and, on the contrary, the water of the upper spring seemed more astringent, and less acid. This induced me to think, that the mineral parts, which caused the acid and astringent tastes, were mixed in the waters of these two springs in different proportions. And what I observed of them afterwards still confirmed this conjecture.

But, in order to give some evidence for the existence of the above-mentioned minerals in the waters of these springs, we shall consider them separately, by relating the experiments, which seemed to indicate, that they are contained in these waters in a very considerable proportion, and by offering some conclusions, which may be reasonably drawn from them.

And as the first trials were made in quest of iron, it may perhaps be most proper to consider it in the first place.

*Experiment 1.* Some pieces of galls being added to equal quantities of the water of the two springs, an exceeding deep and bright blue colour was immediately produced in the water of the upper spring, which in a little time turned to a perfect black. The water of the lower spring, tho' indeed it was turned of the same colour, yet was not of so deep a shade, but was somewhat lighter than the former. The tincture of galls caused the same appearances.

2. A tincture of balaustine-flowers produced the above blue colours in both waters.

3. A quantity of the water being thoroughly tinged with galls, was allowed to stand 24 hours: being then filtrated thro' brown paper, the water, tho' almost quite colourless, would not again receive any tincture with galls.

4. After elixation the water became of a turbid yellow colour with ochre, and afforded very little tincture with galls.

5. A solution of fal Martis, chemically prepared, being mixed with galls, immediately turned of a bright dark blue colour, exactly similar to that produced in the water.

6. A solution of common and rock alum was no-ways changed in its colour with galls.

7. A solution of fal Martis and alum being mixed in equal quantities, the mixture was turned of a bright blue colour with galls; yet not of so deep a hue, but of a more diluted colour than the solution of fal Martis, without alum.

From these experiments we must first of all observe, that the colour, which these waters afford with galls and pomegranate-flowers, is very uncommon. The more iron, that any mineral water contains, it will afford the deeper colour with such astringents: but tho' I have tried this experiment upon a great many of the ferrugineous waters in Scotland, and also upon the water of some of the foreign Spaws, I never observed one, that afforded so deep a colour as this, which we now consider. Some of the weakest of them gives only a red or faint purple tincture, and the strongest only a deep purple: but I never saw or heard of any chalybeat water, but this, either in Scotland.

Scotland or elsewhere, that afforded an intense black and inky colour with galls. From which, I think we may venture to conclude, that the water of this Spaw contains a far larger proportion of iron than most, or perhaps than any, other chalybeat water hitherto discovered : and for this reason, I dare say, it will likewise be so much the more preferable to most others in medicinal virtues ; which has indeed already appeared by many surprising cures it has performed, and which, I am persuaded, will more fully appear, when its medicinal effects shall be better known.

There must needs be a very great quantity of iron in this water, when it yields as deep a colour with galls as a strong solution of sal Martis. I was indeed at first apprehensive, that this perhaps might not be owing so much to a large and uncommon proportion of chalybeat parts, as to the commixture of alum, which I judged to be in the water. But we see the contrary appears by these trials : for alum of itself affords no tincture with astringents, and, instead of rendering a solution of sal Martis with galls of a more intense colour, rather makes it lighter and more diluted.

We see here, that the ferrugineous matter is intirely separated from the water by an infusion of galls. The like also happens by elixation ; after which it is almost deprived of its tinging quality. Yet other chalybeat waters lose this quality by a much less degree of heat.

As there is an ochrous earth separated from all steel waters, when exposed to the air, which subsides



to the bottom, and a metalline scum or cremor, which swim on their surface; we shall next consider the appearances, which they make in this water.

*Exp. 8.* A solution of saccharum Saturni being dropt into common spring-water, left the upper parts of the water clear and colourless, but formed a lactescency towards the bottom. The same solution being added to the mineral water, soon turned it of a turbid yellow colour, which afterwards subsided, and formed a deep yellow cloud in the bottom of the glass; and below this yellow sediment there adhered to the bottom of the glass a whitish substance, which I took to be the metalline parts of the saccharum Saturni separated from the purer parts of the salt, which were still suspended in the water, and which made it of a muddy whitish colour.

9. Forty drops of oleum tartari per deliquium being added to an ounce of the water, made it of an uniform light yellow colour; but in an hour afterwards there were many small yellow terrene *nubeculae* formed in it. These the next day were more conspicuous, being thoroughly separated from the water, and precipitated to the bottom, leaving the water quite clear, as it was before the mixture. A small quantity of this limpid water being taken, it would afford no tincture with galls. It was then all poured off, except so much in the bottom of the glass as contained the above-mentioned clouds: to this there were some galls added, which in half an hour turned these clouds from a light yellow to a deep red colour, but did not change the colour of the water, in which they swam.

10. Immediately after the affusion of ol. tart. p. d. to the water, galls were added to the mixture, which tinged it of a deep and bright red colour. After standing for some time, there were red clouds precipitated to the bottom, and the water continued of a dusky opaque red colour.

11. There is a small brook, formerly mentioned, which runs near by these springs; into which the water, that flows from them, is discharged. I observed the stones and channel of this brook all tinged with ochre of a deep yellow colour, so far up as the water of these springs flowed into it; but the channel, which the mineral water ran over before it was mixed with the water of the brook, was very little or nothing discoloured with ochre. As I conjectured what this was owing to, I afterwards took two equal quantities of the mineral water, into one of which I put an equal quantity of common water. In two hours the mixture became less transparent, and appeared yellowish, while the simple mineral water retained its clearness. Next day there was much ochre separated from the mixture, which subsided to the bottom of the glass: but the unmixed mineral water remained still clear and colourless, as at first.

All chalybeate waters separate their ochrous parts, when exposed some time to the air; but this separation is made sooner by the commixture of several kinds of salts. Thus we see the ochre in this water is immediately separated and precipitated by the solution of saccharum Saturni.

The oil of tartar causes a precipitation of these ferrugineous parts in the same manner. Which parts  
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must be the sole cause, that the water receives a tincture from galls ; since, after they are precipitate, it loses that quality, which they notwithstanding retain even after they are separated from the water. This precipitation of the ochrous parts of the water were the only visible effects that I could perceive to follow from the affusion of the ol. tart. p. d. I remember indeed, when I was at Moffat, I saw the manuscript of Dr. Horsburgh's experiments upon this mineral water ; which appeared to be very accurate ; and which I understand are since printed, in a volume lately published by the Philosophical Society at Edinburgh. Amongst these I observed one, which I thought so very remarkable, that I particularly adverted to it. It was the effects of the affusion of ol. tart. p. d. to the water, producing in it clouds, or a coagulation of a green or grass-green colour. I think these were the words ; and I own I was something surpris'd at them. A solution of vitriolum Martis, mixed with this alkaline oil, does indeed produce a green coagulum : but I could scarcely think, that this, or any other chalybeat water, contained so large a proportion of that vitriol, as to be sufficient to produce these effects, when I considered, that so many writers, which I had seen, upon this subject, have all failed in their attempts of extracting a conspicuous martial vitriol from such mineral waters. I had tried this experiment upon four or five chalybeat springs in Scotland, and likewise upon the Spa and Pyrmont waters, which had been well preserved ; but there never resulted any such effects from the mixture of these with oil of tartar, as are related in the above experiment. All the alteration it produced

duced in these waters was the precipitation of an ochrous earth, but without the least appearance of any green colour. As I looked upon this as a leading experiment in the history of vitriolic waters; as I had often tried it, and as often seen the green coagulum produced with the solution of the factitious vitriol, and never could observe it produced in any of the above water; I began to suspect, that these waters were either not possessed of a vitriolic salt at all, or else, that it was in some respects very different from the factitious vitriol. For these reasons, Dr. Horsburgh's experiment appeared very extraordinary; tho' at the same time I was greatly pleased, that I should have the opportunity of repeating it, and of observing those phenomena in this ferrugineous water, which I had sought for in vain in several others. But when I came to make the trial, I was yet more surprised, when I found it misgive, and that the ol. tart. p. d. produced no green colour or coagulum in this mineral water, nor caused any other alteration in it, than the separation of a large quantity of ochrous earth of a yellow colour, exactly the same with what I had observed in the other steel waters. This failure made me immediately conclude, that I had somehow or other committed an error in the experiment: and tho' I was pretty sure, that the mineral water, which I had used in it, was quite fresh, yet I could not be so positive as to the oil of tartar, which I suspected to have been long kept. Yet that this could have been the cause of my being so unsuccessful, I could scarcely believe, tho' indeed I could assign no other. I was sorry, that I had not afterwards an opportunity of repeating this experiment with more accuracy,

accuracy, from which I might have expected to reap more success, as it is perhaps one of the most consequence, that can be performed on this mineral water, as it is capable of demonstrating the existence of a substantial vitriolum Martis in it; which is more than has been hitherto done, or perhaps ever will be done, concerning any one of the vast number of chalybeate waters, which have been yet discovered.

When galls are added to the water, at the same time with oil of tartar, instead of its deep blue colour, it affords only a red tincture.

It appears from the 11th experiment, that an addition of common water causes the mineral water to precipitate its ochre; and the reason of this is obvious: for if these ochrous parts be altogether terrene, as they appear to be, and exist in the water unconnected with any other principle, then it must happen, that as these parts are uniformly diffused thro' the water, in which they are suspended as in a menstruum; by the addition of common water, this menstruum being diluted, the cohesion of these terrene parts must be thereby weakened, and their contact destroyed; so that their menstrual equilibrium being thus taken off, they can be no longer supported in the fluid, but must be precipitated by the force of their own gravity.

*Exp. 12.* When the water was exposed for some days to the air, there was a cremor separated from it of a shining chalybeate colour. This, like other kinds of cremor, takes a considerable time to complete its entire separation from the fluid, out of which it is expelled: for when it was despumated, a new cremor

cremor always succeeded, until the whole quantity, which the water contained, was exhausted.

13. When this cremor first appeared on the water, it was of a faint blueish colour : but as it increased, it changed into a deeper and more bright shining blue : and, after longer standing, it became blotched with various colours, as red, orange, yellow, green, blue, purple, and violet.

14. A quantity of the water being put in a gentle heat, this cremor was quickly separated from it, and appeared on the surface of the water. A like quantity of the water, with its cremor already upon its surface, was put over a gentle heat, which by degrees broke the cremor into very small parts ; but whether they did evaporate, or precipitate in the water, I could not be certain. But, by other trials, this cremor was found to have a great degree of fixity, bearing a considerable heat without avolation ; yet not without the appearance of some of its parts flying off, altho' most of them were fixed ; because what remained lost its fine colours, and was changed into a shining chalybeat colour.

15. The water of the lower spring afforded a much less quantity of the cremor, than the water of the upper spring. It took also a longer time to separate, was of a blueish colour, and had not the vivid colours, which the water of the upper spring shewed.

16. When ol. tart. p. d. and spirit of sal ammoniac were added to the water, it did not separate its cremor.

This cremor, which is separated from the water, is the same with that, which appears on the surface of

a solution of vitriolum Martis, when exposed for some time to the air: and an infusion of iron in common water also emits a cremor of the same kind. I remember, as I was once carefully observing a large glass full of a chalybeat water, which contained much of this cremor; soon after it was exposed to the air, I observed a tenuous blueish vapour rising in the parts of the water next the surface, which very much diminished its transparency; and by degrees this vapour was emitted by the lowest parts of the water: but as the cremor increased on its surface, the water became gradually deprived of the blueish tincture, which it received from this halituous body; which was apparently nothing else but the parts of the cremor separating from the water, and ascending upwards. From whence we may conclude, that this cremor consists of the very finest parts of iron attenuated to the highest degree.

It has been the opinion of most naturalists, that these kind of mineral waters do abound in sulphureous parts. This they have conjectured from the foetor, that often attends them. But in what quantity or form these parts exist in the fluid, or by what means they can be rendered conspicuous, has not as yet been sufficiently determined. Yet, I think, we may suspect some of the parts of this cremor to be sulphureous. They are volatile, and, being heated, do fly off from the pure metalline parts, which being more fixed, are thereby left destitute of those vivid colours, which they enjoyed from the sulphureous parts. These are evident marks of sulphur, and are altogether analogous to some other appearances of that mineral. Another observation tending to support this is the want of those vivid colours in the cremor,

cremor, which appears on an infusion of iron ; the reason of which seems to be the loss of the sulphureous parts of the chalybeat minerals by avolation, during the operations of the fire, which they undergo in refining.

It appears from the fifteenth experiment, that the water of these two springs contains a very different proportion of this cremor : and from the last, that it is precipitated along with the ochrous parts, which happens upon the affusion of these alkaline liquors.

The next trials were in quest of alum.

*Exp. 17.* A quantity of the water being kept for some time in a boiling heat, and after it was cool being filtered quite clear from its ochrous matter, it still retained a subacid and aluminous taste in a very strong degree.

18. To an ounce of common spring-water there was added two gutts of fresh sweet milk. This mixture being shaken, the milk mixed intimately with the water, without any kind of coagulation.

19. The same experiment being made with the mineral water, the milk, upon its affusion, was so curdled, or separated into clouds, that the greatest shaking could not mix or incorporate it with the water.

20. This experiment being also made with a weak solution of alum in spring-water, its effects upon the milk were not in the least different from those of the mineral water.

21. And the same trial being again repeated with



the water, when boiled and filtered from its ochrous parts, the milk was in the same manner coagulated as before elixation.

22. One part of sweet milk being added to four parts of the mineral water, the milk subsided, and formed a cloud in the bottom of the glass, leaving the upper parts of the water clear. This mixture being heartily shaken, the milk mixed so well with the water, that it appeared to be but a very little curdled.

23. When a larger quantity of milk was added to a smaller quantity of water, and even when equal parts of the milk and mineral water were mixed and shaken together, there could be no curdling or coagulation observed.

24. An equal quantity of the water and milk being boiled together, the greatest part of the milk was coagulated into a thick white curd; and the remainder, with the mineral water, turned of a pure white milky colour, which drank like whey, and was very agreeable.

25. Eight gutts of sweet milk being added to four ounces of the water, and the mixture boiled, part of the milk was thereby curdled, and swam upon the top of the water. The ochrous parts of the water were likewise separated, and falling to the bottom, their colour did not appear of a clear yellow, as usual, but was something milky.

All these experiments strongly indicate the existence of alum in this water. It retains its aluminous taste, and coagulates milk, after the chalybeate parts are almost all expelled by elixation. The coagulation.

tion of the milk demonstrates an acidity in the water, and the other appearances shew that acidity to be owing to an aluminous salt.

It appears, that the milk requires a large quantity of the water, to make a sensible coagulation in it: for, in the 22d experiment, one part of the milk being added to four parts of the mineral water, the coagulation was scarcely discernible: and in the 23d, when an equal or larger quantity of milk was added to the water, the coagulation was not at all observable. I have heard it confidently averred, that this mineral water did not at all curdle milk; which, I suppose, has been thro' a mistake in the experiment, in adding too large a proportion of milk to the water: for in this way the coagulation cannot be observed.

I imagined, that when the water was boiled with milk, the mixture would have become of a muddy yellow colour, by the separation of the ochre: but it did not even appear, that the ochre was at all separated from the mixture, as it is from the water when boiled by itself. On the contrary, not only the coagulum, but also the liquor, was of a pure white colour, and of a pleasant taste: and this makes me think it worth the inquiring into, whether or not the water does retain its medical qualities after it is prepared in this manner with milk? For, if it does, such a preparation might certainly be very serviceable in many cases.

These experiments, which we next relate, do not only ascertain the existence of alum in the water with greater certainty, but also, that there is a particular kind of earth conjoined with this salt.

*Exp.*

*Exp.* 26. An English quart of the water being kept boiling for a quarter of an hour, it turned thick, muddy, and yellow, by the separation of its ochrous parts; and, being set to cool in a clean bowl, the next day all the ochre was subsided to the bottom, from which the water was carefully filtered: whereby it became almost as clear and limpid as before the elixation, retaining a sharp aluminous taste, but was deprived of the strong ferrugineous taste, which it had at first. This water was again boiled; by which means it was again turned a little yellow, by the separation of some more ochre. It was therefore again filtered, and rendered clear, and its aluminous taste was stronger than before. After this filtration, the water was evaporated in a sand-heat to about a sixteenth part of the original quantity, and then it tasted like a strong solution of alum joined with a small degree of a chalybeate taste. And this being totally evaporated in a glass, there adhered upon its sides a pure white salt; and a larger quantity of the same salt remained in the bottom of the glass, which was not so white, but more impure than the former, and of a brown colour.

27. This salt, thus procured from the water, being mixed with distilled vinegar and spirit of vitriol, there was not the least effervescence produced.

28. Some of the brown-coloured salt being put upon a red-hot iron, it did neither sparkle nor decrepitate; but was turned into a blackish cineritious substance, which in a short time became a white calx. And tho' some of the salt was put upon the iron finely powdered, yet it concreted, and run together in a cinder, whose cohesion was afterwards destroyed when calcined by a further degree of heat.

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29. As I was accidentally deprived of the opportunity of obtaining the crystals of this salt, which would have been the best means of knowing to what species it was to be referred ; I dissolved the whole mass in a small quantity of spring-water, and, by filtrating this solution, I obtained a large proportion of fine earth of a brown colour.

30. This solution of the salt afforded a deep blue tincture with galls.

31. The same solution, being mixed with syrup of violets, became of a reddish colour.

32. Saccharum Saturni being added to the solution, precipitated a thick lactescent cloud.

33. Ol. tart. p. d. being also added to this solution, it caused no visible effervescence, yet raised some bubbles of air, and caused a coagulation of many small brown terrene nubeculæ in the water ; which, after standing some time, subsided to the bottom, and left the water clear.

These experiments do plainly evince, that this water contains an aluminous salt, conjoined with a fine terrene substance, which is probably a part of the matrix, from whence the salt has been formed.

This salt gives no signs of any alkaline principle ; but, on the contrary, of an acidity, as its solution reddens with syrup of violets.

With this salt there are also intimately conjoined some very subtil chalybeat parts, which are not separable from it by elixation or evaporation.

Alum is distinguishable from all other mineral salts, by liquifying and bubbling upon a red-hot iron, and turning into a white calx. But this could not be well expected from this aluminous salt, which we

had extracted from the water, because it was extremely foul, by being combined with so large a proportion of earth; which earthy parts were the occasion of turning the salt of a blackish colour upon the iron. However, we see it turns white by a further degree of heat. But if the salt had been dissolved, filtrated, and crystallized, till it had been purified and freed from this terrene matter, it would then certainly have had the same appearance upon the red-hot iron, as a pure aluminous salt. Again, as it is peculiar to an aluminous salt to liquify in some degree with fire, so we see, that this was evidently the case of this salt. Its eliquation indeed could not be so remarkable, as in pure alum, because of its being mixed with so much earth; but that it did liquify in some degree is plain, because the whole mass of salt and earth, even when reduced to a powder, ran all together like a cinder.

The experiment upon the solution of this salt with ol. tart. p. d. is also a further proof of what we have already asserted: for tho' there was no visible effervescence, yet the bubbles of air shew, that there was an intestine conflict of the oil with the acid principle in the solution; which being absorbed by the alkali, the earth was precipitated, to which it formerly adhered.

The two next experiments were made in order to discover, whether an acid or alkaline principle prevailed in the water.

*Exp. 34.* Forty gutts of the syrup of violets being added to an ounce of the water, the mixture became of a bright sea-green colour.

35. A quantity of the water being kept boiling for five minutes, and afterwards allowed to stand till it became clear, was carefully filtrated from its ochrous sediment: after which, upon its mixture with syrup of violets, it turned of a faint reddish colour.

From these experiments we infer, that this mineral water contains both an alkaline and an acid principle; the former consisting of the ochrous and ferrugineous parts, which are separated from the water by elixation; and the latter of the aluminous salt, which remains in the water after elixation.

The following trials were made in order to know what effects are produced in the water by being exposed to the air; and in what respects the waters of the two springs differed from each other.

*Exp. 37.* An English quart of the water of each of the springs being fully exposed to the air in two China bowls, the next day that of the under spring was neither altered in its taste, colour, or transparency, nor in any other shape whatever; but that of the upper spring appeared of a yellowish colour, altho' it was clear and transparent as the other.

On the second day the taste of the waters scarcely appeared to be any way diminished. No sensible change could be observed in the lower water; but the upper water was become more yellow than it was the day before, yet without any loss of its transparency. They both tinged of a deep blue colour with galls; which tinctures appeared equally deep

and strong, as they did before the waters were exposed to the air.

The third day the lower water appeared clear and colourless as before, only its surface was covered with a few small spots of cremor. The upper water appeared more yellowish than formerly, and its surface was almost wholly covered over with the cremor. They both afforded a tincture with galls, which was not sensibly different from what they gave before their exposure.

On the fourteenth day the water of the under well had precipitated a yellow ochrous sediment, but the other water a more considerable quantity. A large quantity of cremor continued also to swim upon the surface of the upper water, but there was very little separated from the water of the under well. Both waters being now tried with galls, instead of the deep blue colour, which they did formerly exhibit, they now became only of a deep purple colour.

On the twentieth day the visible appearance of both waters was the same as when last observed.

On the thirty-eighth day they both afforded as deep a purple colour with galls, as they did three weeks before; and during that time also they had not precipitated any more of their ochrous parts, nor suffered any other sensible alteration.

The water of the upper well being filtrated from all the ferrugineous matter, which it had separated during these thirty-eight days, was rendered almost as limpid and clear as when newly taken from the well: but, being boiled for some time, it became of a turbid yellow colour; and being allowed to stand,  
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it again precipitated abundance of an ochrous sediment ; and being filtrated, and mixed with galls, it received a faint purple colour of a blueish hue.

38. A bottle of the water of each of these springs, being carefully sealed, carried to Moffat, and kept for two months, suffered not the least alteration during that time, but was as fresh as when immediately taken from the fountain. And I am informed, that after it is carried to Edinburgh, and to places at a greater distance, it will keep a much longer time without being any way spoiled.

I believe it will appear from these observations, that this mineral water continues longer intire, and particularly that it retains the quality of tinging with galls longer, than most others of the chalybeat kind : at least, of a great number, which I have seen described, I do not remember one, that retains it near so long, when exposed to the open air. Many of them lose this quality intirely in a few hours ; and it is greatly impaired in the same time, even in those which retain it longest. But this water, we see, remains exposed to the open air for days, without almost any alteration. This may perhaps be owing either to the larger proportion of ferrugineous parts, with which it is impregnated ; to their being attenuated to a greater degree ; or to their more perfect commixture with the water, by means of the aluminous salt. The longer time, that any mineral water does remain intire, without any separation of its mineral parts ; or the longer it retains the same form, which it has when newly taken from the spring ; the more perfect is the commixture of these parts with their



fluid vehicle: and I believe, upon that account, will be more effectual for medicinal uses: for which reason, I suppose, these waters may prove a more beneficial medicine, than any others of the ferrugineous kind, whose mineral contents are not so intimately commixed with the aqueous fluid.

As these waters are so long in separating their mineral contents, they appear particularly well adapted for being transported to distant places: for by this quality they are fitted to undergo a long carriage, and to be kept a considerable time, without any diminution of their medicinal virtues. It must also be noticed, that the water of the under well is by much the best of the two for carriage, or for being long kept, as it is longer in separating its mineral contents than the upper one.

From these experiments it is evident, that there is a considerable difference betwixt the waters of the two springs. The upper one contains a much larger quantity of the ochrous earth, and metalline cremor, than the under one; which is the reason, why it yields a deeper colour with galls, as may be observed in the first experiment. I suspected, on the other hand, that the under water contained a greater proportion of alum, than the water of the upper spring; but this I cannot affirm, as I find I had neglected to make the experiment, which would have determined whether it be so or not. Tho' the mineral contents of these two waters be similar, yet, if they be thus mixed in them in different proportions, this must certainly create a difference between them, which deserves to be attended to, as it may be sufficient to disallow of their being used promiscuously, since their medicinal effects may be thereby different.

But

But now, to sum up the evidence, which these experiments, taken all together, do afford, concerning the mineral ingredients of this Spaw; I think they determine, with some degree of certainty, that it contains two different principles of iron, both of which are fixed. The one, which is the ochrous earth, is a true *minera ferri*, and, altho' it be a crude mineral, exists in the water in a very fine and subtile form; the other, which is the cremor or pellicle, whose parts are also extremely attenuated in the water, appears to be iron, not in its mineral, but in its metalline form, and, when thrown up upon the surface of the water, shews itself like an extreme thin *lamina* of that metal. There seems also to be some small proportion of fulphur joined with the metalline cremor. The other mineral ingredient, which enters into the composition of this Spaw, is a considerable proportion of an aluminous salt, which is conjoined with a small quantity of a light brown-coloured earth (probably a part of the matrix whence the salt is formed), and still more intimately connected with some of the chalybeat parts of the water, which are not separable from it either by elixation or evaporation. Whether these be saline or terrestrial, I cannot determine.

Having thus endeavoured to discover, by some plain and simple experiments, the mineral principles, with which this medicinal water is impregnated; I shall now only add some observations, with respect to the origin of steel waters, and particularly of this Spaw, whose origin, I think, is thereby discovered and ascertained in a very obvious manner.

Among

Among several things, that are still deficient in the history of mineral waters, an exact knowledge of their origin seems to be the chief; that is, from what fossils, and in what manner, these waters do acquire the mineral substances, with which they are impregnated. As this happens in the bowels of the earth, and is therefore far removed from our view, it is not surprising, that there has been so little discovered concerning it; tho' indeed there have been many elaborate hypotheses framed in order to account for it.

The writers on mineral waters have been of very different and opposite opinions concerning their origin. They have disagreed widely amongst themselves; and I very much suspect, that the accounts, which most of them give of this matter, are not agreeable to truth: particularly with respect to chalybeate waters, I have seen none, who have given a satisfactory account of their origin. They have all agreed, that iron, or the vitriol of that metal, does exist in mineral waters; but they have never yet agreed, how they came to exist in them, or in what manner mineral waters come to be imbued with these fossils.

Some of the more ancient writers cannot comprehend, how simple water should be intimately impregnated with so many different kinds of minerals, except by the means of some powerful agent. And as they thought nothing more proper for communicating and mixing mineral substances with water, than violent heat, they therefore termed all mineral waters, of whatever kind, by the name of *thermae*. They saw some spring from the earth extremely hot, others moderately hot, others tepid, others excessively cold:

cold: they concluded from this, that all such various degrees of heat in these waters were owing either to the different degree of subterranean fire, which they had undergone; or else to the great distance, which some of them had run in the earth, after they had been sufficiently heated. They therefore maintained, that those waters particularly termed *acidulæ* (the greatest part of which are impregnated with iron), or those, which, tho' intensely cold, contained a large proportion of mineral matter, had in some part of the earth been impregnated with it, by means of an intense heat, which they had been gradually deprived of by a long passage thro' the colder parts of the earth.

Some naturalists again, of a later date, having exploded the former notion as chimerical, have thought, that a vapour rising from vitriolic minerals, and mixed with the neighbouring streams of water in the bowels of the earth, has imbued them with some of the parts, and with the properties, of vitriol.

Others are of opinion, that the exhalations of vitriolic minerals, passing thro' the cavities of the earth, are there condensed by the subterraneous cold into a limpid fluid, containing the very finest parts of that mineral salt: which fluid, mixing with the præterlabent streams of water, and issuing out of the earth with them, produce those mineral springs called vitriolic.

The last opinion I shall mention on this subject, and which indeed appears the most plausible, is of those, who think, that the iron is corroded and dissolved in these waters by means of an acid: for, as they imagine simple water incapable of doing this,

they suppose, that it is first imbued with an acid in the bowels of the earth; and then, by the corrosion of the chalybeate minerals, thro' which it runs, it comes to be impregnated with them. I once received this opinion, as the most probable I could then observe, concerning the origin of these springs: yet not as being satisfactory; for there are many objections against it, which it is difficult either to elude or to answer.

The supposition of an acidity in ferrugineous waters, I thought but ill confirmed, because, upon trial, they discover no vestiges of it, but rather appear to be alkaline. Besides, in considering the causes of mineral waters, it seems more probable, that whatever minerals they contain, they must be such, as can be received or extracted by common water in its passage thro' the earth, by solution, abrasion, or the like simple operations; and in this way alone I think we may come to account not only for the commixtion of the saline and terrene minerals, which are found in medical waters, but likewise of those, that are metalline or sulphureous; for which simple water, at first sight, may perhaps seem to be an insufficient solvent.

It was this notion, that first induced me to make trial upon various mineral and metallic bodies, in order to know how far they could communicate their virtues to common water by infusion. I thought this might throw some light upon the origin of mineral waters: yet, tho' I made a great many experiments of this sort, and particularly upon several kinds of native chalybeate minerals, I was as little satisfied concerning their origin as before. I at length, however,  
met,

met, by accident, with what I had inquired after with so little success.

As I happened to be at a gentleman's house near Edinburgh, in whose estate there was a great deal of coal, and who was at that time working a level or adit, in order to drain off the water, I observed, that the current of water, which flowed from this level, separated a great quantity of ochre, and, emptying itself into a river soon after it came from the entry of the level, tinged all the stones and the channel of the river, for a good way, of an ochrous colour. The taste of this water was exactly like that of a common steel Spaw; and it afforded a purple colour with galls\*. As I knew, that this water flowed off a great body of coal, I often infused that fossil, taken from the pits near this level, in common water; but the infusions never yielded any tincture with galls. I tried in the same way another mineral, that the miners call *blaes*; which is a cliffery stratum of a blueish colour, that often lies both above and below the coal: also another fossil of a brown colour, which is very ponderous, and is called by the miners *dogger*; a thin seam of which often lies in the midst of the coal. However, neither of these would afford an infusion, that would tinge with galls. At last I got another mineral out of these coal-pits, which is sometimes found amongst the coal, but is not so frequent as any of the former; and this fully

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\* Within two miles of this place there is a steel Spaw of good repute for the performance of several extraordinary cures, which gives the same tincture with galls, and appears in every respect to be the same with the water, that flows from this level.

answered my expectation. It is found either in round or broad pieces, is exceeding ponderous, and of a shining yellow colour, and is called by the miners *brass lumps*. When I infused this mineral for a short time in common water, it communicated to it all the properties of a steel Spaw; its taste was exactly the same; and it received a tincture from galls, which was of a more diluted or intense purple, according to the proportion of the mineral added to the water, or to the time of the infusion. This simple experiment does therefore clearly discover to us the origin of steel waters, and the manner, in which they are impregnated with their mineral contents in the bowels of the earth.

This observation, which I had made concerning the origin of steel waters, led me, when I first visited Hartfell-Spaw, to inquire into the adjacent fossils: which was the more easily done, as the strata of the earth about the well, for a considerable depth, are exposed to view. After some search among these, I found a stratum of cliffery rock, about three or four feet thick, of a grey colour, and, I think, about twenty paces from the spring. In some of the hollow places of this rock, where the rain and wind did not reach, I observed a white saline efflorescence on its surface, which when I had taken off and tasted, I concluded, from its styptic and chalybeate taste, that it was a native vitriolum Martis, notwithstanding its white colour; but I found it, upon trial, to be alum, having some fine attenuated parts of iron conjoined with it, and the same salt with that contained in the Spaw water.

Having

Having taken some pieces of this rock, which were quite free from the saline effervescence, and infused them in common spring-water for some hours, this water did thereby acquire the true taste of the Hartfell-Spaw. It likewise in the same manner received a deep blue tincture with galls, and contained all the other qualities of that mineral water, without the least difference, that I could observe: which, I think, ascertains the true origin of this mineral spring in the most obvious and undeniable manner.

I am persuaded, that this plain and easy method of investigating the origin of mineral springs is not only superior to the most learned discussions and elaborate theories, but will be found to be the surest, yea. the only way of extending and compleating our knowledge concerning them. As I have not yet had the opportunity of making the experiments, which I designed, upon the two fossils, that we find to be the cause of the above mineral waters, and which will be necessary to elucidate and compleat these observations, which we have made concerning their origin; I shall now only add one thing, and recommend it to the observation of others: “ *Whether or not, from such a knowledge of the origin of mineral waters, we may not acquire artificial ones of as great, or perhaps of greater, medicinal use, than those, which are naturally produced?* ”